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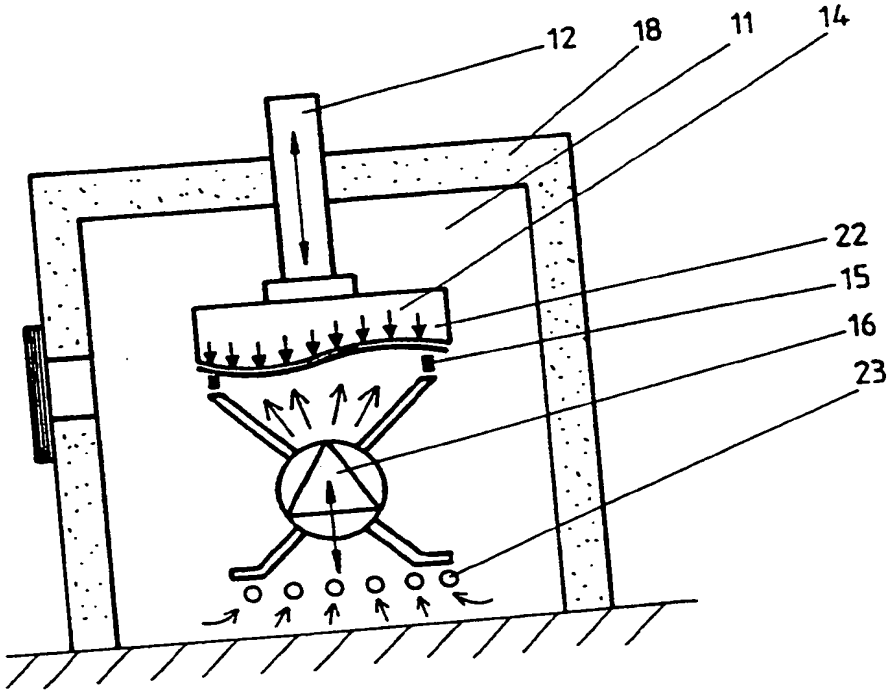

(57) Abstract

The invention relates to method and equipment for bending glass. In the method the glass sheet is bent against the mold (14) so that the bending of the glass sheet is achieved by air blowing or pressure and by means of a ring mold (14). Preferably the air film is achieved between the mold (14) and the glass (3) whereby the suction and/or blowing holes (22) are situated into the mold (14) for enabling the special bendings.

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METHOD AND EQUIPMENT FOR BENDING AND/OR TEMPERING GLASS SHEETS

The subject of the invention is glass bending and/or tempering system and -equipment, particularly for difficult bends such as automotive windshields, backlites and sidelites.

Glass is bent and tempered by various methods. In one of prior art bending and tempering systems, still in use, the glass was first heated in the furnace on ceramic rollers. As the glass was advancing, the roller bed changed to gas bed. This means, that there was a flat plane with holes through which hot air was blown, which simultaneously heated the glass and carried it on a thin film of air. When the glass reached the bending temperature, this gas bed gradually changed from flat to required shape, normally to a radius type bend. The glass bent by gravity to the shape of the gas bed, but as the glass was continuously moving forward, understandably the glass could not have conical or complex shapes. Fig. 1 shows this kind of schematic arrangement of so called gas heart furnace.

In another bending method known in French patent 2567508 (Fig 2), the glass 3 is heated in a roller heart furnace 2 to the bending and tempering temperature, then the glass 3 is formed against a mechanical mold 4 by blowing hot air by blower 6 through air channel 7 against the glass 3, thus forcing the glass to the shape of the mold 4. In this case air blowing alone is used to bend the glass. The principle of this method is described in Fig 2. Some disadvantages of this method are, for example, that the glass has to be heated into the high tempering temperature on ceramic rollers, which is liable to cause damage on the glass surface, the positioning of the glass against the upper mold has to be made very precisely, since if the glass is not accurately correctly positioned with respect to the mold, the bending will be incorrect. The glass, which is in tempering temperature, is very difficult

to position correctly in hot furnace. Also additional heating is difficult, and it cannot be done from below by radiation due to the ceramic rollers and air ducts. Since the glass forming against the full mold is accomplished fully by dynamic pressure (kinetic energy) of the air blowing only, the bending takes time, required air quantities are high and the method is energy wasting and hard to control.

It is also possible to use such a method which is known from the Finnish patent application 903397, in which the glass is bent to the shape of the ring mold and then, using for example a "ceiling" system, a pressure difference is created between the topside and the bottom side of the glass. The pressure difference supports the glass partly or fully and then the glass can be further heated to even and high enough temperature for tempering. With this method, however, it is not possible to make glasses which have S-shapes or very complex shapes, because the pressure difference can only compensate the gravity, but cannot form the glass.

With the inventive method and equipment remarkable improvements are achieved for the drawbacks of the prior art methods described. Characteristics to carry out this inventive method and equipment are as outlined in patent claims 1 to 7.

The advantages of this invention are the suitability for particularly difficult glass shapes. The invention makes possible to produce not only automotive backlites and sidelites, but also windscreens bent to S-shape, certain interior design and architectural glass cheaper than with competitive methods. Bending/tempering process with the inventive method is more easy to control, because the glass is bent and heated to the highest temperature, when it is liable for optical deformations due to its plasticity, stationary, in its final location in the furnace. Air blowing volumes are lower than in the prior art top mold method, because the bending is substantially assisted by ring

mold. The central areas of the glass do not ever touch mechanical supports or rollers, which makes the glass optical quality very high.

It is known to utilize mechanical presses to press the glass against the full face mold, but every glass would require a press of its own and mechanical presses leave easily marks on the glass. Mechanical presses in the hot furnace cause a lot of expenses due to their service, adjustment and change. The pressing in this inventive method takes place by air pressure, therefore the pressing is even and no marks are left on the glass. Air pressure also conforms to any shape and no separate molds are required on the side of the air pressure. Due to these reasons the inventive method improves the glass quality and saves expenses.

Difficult glass positioning or transfer from rollerbed to ring mold inside the furnace is not required or it can be made at glass temperatures well below 600 degrees centigrade. In low temperature it is much more easy to make than in about 620 degrees centigrade temperature, in which temperature it has to be made with the competitive methods.

The prior art and inventive methods and equipment are described with reference to the following drawings. The drawings describe:

Fig. 1 a schematic presentation of so called prior art "gas heart furnace" with section A-A.
Fig. 2 shows earlier described prior art French method.
Fig. 3 shows a schematic arrangement of the invention
Fig. 4 and 5 show alternative arrangements of the invention.

Fig. 1 is a schematic arrangement of so called gas heart method in which the glass is brought on the rollers to the first heating stage, after which the roller heart changes to gas heart furnace 2, in which blown gas supports the glass 3. When the glass 3 is in the bending temperature, the gas heart

gradually takes the required shape. The section A-A shows this part. Tempering is the final stage of the process. As the glass moves all the time, it cannot have conical or complex shapes.

With the inventive method in Fig. 3 the glass 3 can be shaped into particularly complex shape. This is achieved by using a full face mold 14, which is identical with the shape of the glass and which normally is a male mold. The glass shaping is performed by pressing combining static or dynamic air pressure to the use of the ring mold 15. During and after bending the final glass heating to the required temperature takes place.

If the final glass bending takes place utilizing ring mold and advantageous static air pressure, it is a must, that the other half of the furnace, (bottom part in Fig. 5), forms a closed space, in which in one side, (in Fig. 5 in top part), there is an opening slightly smaller than the glass. The shape of the opening is similar to the glass shape and the edges of the opening are similar to the bend of the glass edges. It is most advantageous to make this opening by a replaceable collar 20, which is changed according to the glass to be processed. As the glass in Fig. 5 bends and closes the opening, the other half of the furnace section forms a closed chamber 21, into which it is possible to create a pressure by blower 16 blowing there air through ducts 24, by which the glass can be formed against the full face mold which is located on the other side of the glass. For example electrical resistances 23 can be used to elevate the glass temperature further. The jacks located under the bottom section of the furnace make it possible to move the bottom section of the furnace vertically in relation to the mold 14 thus making the described bending possible. The picture also shows a separate chamber 25, into which air can be stored, and which evens up air volume changes caused by pressure variations and in which the air temperature can be regulated to the suitable level by heating elements 26. One

way valve 27 allows the air, which may have leaked to the top section of the furnace during bending, to flow in to the pressurized furnace section through chamber 25.

Picture 4 describes another way to make the furnace bottom section a pressurised chamber 21, in which the heating elements are located and by which the described combined heating and bending process can be accomplished. The needed vertical movement is now achieved by a plate 19 and the sealings connected to it. In this case the other walls of the chamber remain stationary. The picture 4 and 5 differ from each other by mechanical arrangement only, but the process in both cases is the same. The pressurized chamber arrangement reduces air flows, bends much better deep bent glass and makes more localized heating possible for better glass quality and easier control.

If the static pressure was substituted partly partly by dynamic pressure (kinetic energy) of the air, in other words dynamic pressure, no such enclosed furnace section would be needed. The Fig. 3 describes this kind of schematic picture of the furnace or furnace section 11, in which the glass 3 is bent by the lifting device 12 moving up/down the mold 14 and blowing hot air by the blower 16 against the glass. By the heating elements 23 the additional heat can be given to the glass via the air. The glass edges are again bent against the full face mold 14 by ring mold 15. The bending gas pressure in this kind or arrangement is partly static, partly dynamic pressure. Air flows become higher and there is more risk for uneven glass heating. Somewhat improved localized glass heating can be obtained if the resistances 23 were located after the blower, near the glass.

In all cases either the ring mold (or the collar) or the full face mold or both must be vertically movable. The bending is accomplished by pressing the ring mold (or the collar) and the full face mold against each other by the glass in between. The glass is then in low bending temperature,

normally well below 600 degrees centigrade. Simultaneously air blowing takes place so that the air static or dynamic pressure forms the glass against the full face mold in the area limited by the ring mold or the collar. Simultaneously also glass heating is continued until such a final glass temperature that is required in each case. With tempered glass it is about 620 degrees centigrade, for bending only often somewhat less.

Mechanical contact between the hot glass and the mold may cause deformations on the glass. Especially with more difficult bends, which include S-shapes, there is a relative movement between the glass and the mold, which would further add the deformations on the glass. With the glasses which have been decorated by silk printing, it is particularly important to eliminate mechanical contact. For this purpose holes can be added to the mold to facilitate air blowing in between the mold and the glass. In this case the glass is actually formed against the film of air. The air blown through the holes can also be used for heating up the glass. These holes can be added to the mold with any of the arrangements shown in pictures 3, 4 and 5.

In all embodiments of the invention the glass can be easily further heated, from the bottom side in addition to the radiation for example by hot air and from the top side by the hot mold and keeping the air blow at such a temperature that it heats the glass to the needed temperature (about 620 degrees centigrade for tempering), depending on the glass thickness.

When making tempered glass it is possible to transfer the glass to the quench by the same ring mold, on which it has been bent. However, when the full face mold includes holes, it is possible to utilize it as a vacuum lifting device for example for transferring the glass to the quench ring. In this case the quench ring can be located outside of the furnace. The glass can also be supported by blowing it from

below strong against the full face mold in such a way, that it totally lifts up from the ring mold leaving such a gap between the ring mold and the glass that a quench ring, located outside of the furnace, can be brought under the glass. As the blowing intensity is reduced, the glass descends on the quench ring. In this case a film of air is always maintained between the glass and the full face mold, which has a very positive impact on the glass quality, for example mechanical touch on the glass is limited to the edges only.

The preliminary heating stages of the inventive method could comprise of the furnace similar to the windscreen bending furnace, in which case the glass would be transported on the ring mold all the way. The preliminary heating can also take place in a roller heart furnace, in which case the glass must be transferred from the rollers to the ring mold by a vacuum lifter or other similar method for bending. In a very low capacity furnace the glass can be heated in the final bending section right from the beginning. When tempered safety glass is produced, the quenching and the final cooling take place as is normal practise in the industry.

It should be noted, that the inventive method is described using some alternative methods only. This is not meant to limit the invention to these examples only, as various other modifications are possible within the following patent claims.

PATENT CLAIMS

1. A method for curving the glass sheet (3), in which method the final bending and heating to the final (normally highest) temperature c h a r a c t e r i z e d by the glass (3) being bent by combined effect of the ring mold (15) or the collar (20) and the gas (normally air) pressure, against the full face mold (14), which is located on the other side of the glass (3) so that the glass (3) is formed to the shape of the full face mold (14) increasing the glass (3) temperature to the temperature required for bending and / or tempering either by the heat of the full face mold (14) or by hot air blown through the holes (22) thereof or their combined effect on the full face mold (14) side of the glass and on the other side of the glass by hot air blown on the glass (3) or by radiation (23) or their combined effect until the required degree of bending and / or required glass temperature for tempering is achieved.

2. A method according to the claim 1 c h a r a c t e r i z e d in that there on the ring mold (15) side or collar (20) side of the glass and in the same time on the bending pressure side of the glass there are the heating resistances (23) or air blowing system (16) or other heating elements by which the glass (3) can be heated during and if needed after the bending process, to the highest required temperature.

3. A method according to the claim 1 c h a r a c t e r i z e d by the holes (22) which are located into the full face mold (14) through which hot air can be blown in between the full face mold (14) and the glass (3) in order to heat up the glass and / or to prevent the glass (3) from touching the full face mold (14).

4. A method according to the claim 1 c h a r a c t e r i z e d by the adjustable air flow from below so that the glass (3) can be kept up against the full

face mold (14) by air blowing although the ring mold (15) and / or the collar (20) are about 50 - 100 mm under the glass (3) so that the glass (3) can be transferred on to a separate quench ring, for instance.

5. A method according to the claim 1
c h a r a c t e r i z e d by the static gas bending pressure being created in chambers (21), which are formed of enclosed furnace sections having heating elements (23) together with the glass (3) conforming opening, which opening is covered by bent glass (3) so that the pressure, which forms the glass (3) against the full face mold (14), can be created and additional glass heating can be effected by heating elements (23) and mold (14) together with possibility of hot air blowing through the holes (22).

6. A method according to the claim 1
c h a r a c t e r i z e d by the functioning means which moves full face mold (14) and / or ring mold (15) and / or collar (20) vertically up / down so that the bending and the heating process described in the claim 1 become possible and the horizontal movements of the ring mold (15) so that the transfers into and out of the bending/heating section are possible.

7. The apparatus by means of which the glass (3) is bent and heaten to the final required shape and / or temperature include a furnace or furnace section, and is
c h a r a c t e r i z e d by the heating resistances (23) and / or air blowing system (16) or other heating system which are located on the ring mold (15) and / or collar (20) side of the glass (3) and on the other side of the glass (3) there is a full face mold (14) with the possible air holes (22), by which the glass (3) can, during and after the bending, be heated to the highest required temperature. For bending on one side of the glass (3) there is a ring mold (15) and / or collar (20) which limit the area of the glass (3) on which the air pressure is exerted by the blower (16)

thus bending the glass (3) against the full face mold (14) by the combination effect of the air pressure and the ring mold (15) or the collar (20) simultaneously continuing the glass heating up to the final required temperature, together with functional equipment and control equipment needed to accomplish the necessary process.

AMENDED CLAIMS

[received by the International Bureau on 26 November 1992 (26.11.92);
original claims 1 and 4 amended; original claim 5 deleted;
remaining claims unchanged and renumbered (2 pages)]

1. A method for bending and heating the glass sheet (3) to the final (normally highest) temperature in which method the glass (3) is bent by combined effect of the ring mold (15) or the collar (20) and the gas (normally air) pressure, against the full face mold (14), which is located on the other side of the glass (3) c h a r a c t e r i z e d by that the glass (3) is formed to adapt the shape of the full face mold (14) in the furnace section (11) increasing at the same time the glass (3) temperature to the temperature required for bending and / or tempering either by the heat of the full face mold (14) or by hot air blown through the holes (22) thereof or their combined effect on the full face mold (14) side of the glass and on the other side of the glass by hot air blown on the glass (3) or by radiation (23) or their combined effect until the required degree of bending and / or required glass temperature for tempering is achieved.

2. A method according to the claim 1 c h a r a c t e r i z e d in that there on the ring mold (15) side or collar (20) side of the glass and at the same time on the bending pressure side of the glass there are the heating resistances (23) or air blowing system (16) or other heating elements by which the glass (3) can be heated during and if needed after the bending process, to the highest required temperature.

3. A method according to the claim 1 c h a r a c t e r i z e d by the holes (22) which are located into the full face mold (14) through which hot air can be blown in between the full face mold (14) and the glass (3) in order to heat up the glass and / or to prevent the glass (3) from touching the full face mold (14).

4. A method according to the claim 1 c h a r a c t e r i z e d by the adjustable air flow from below so that the glass (3) can be kept up against the full face mold (14) by air blowing although the ring mold (15) and / or the collar (20) are under

the glass (3) so that the glass (3) can be transferred on to a separate quench ring, for instance.

5. A method according to the claim 1 c h a r a c t e r i z e d by the functioning means which moves full face mold (14) and / or ring mold (15) and / or collar (20) vertically up / down so that the bending and the heating process described in the claim 1 become possible and the horizontal movements of the ring mold (15) so that the transfers into and out of the bending/heating section are possible.

6. The apparatus by means of which the class (3) is bent and heaten to the final required shape and / or temperature include a furnace of furnace section, and is c h a r a c t e r i z e d by the heating resistances (23) and / or air blowing system (16) or other heating system which are located on the ring mold (15) and / or collar (20) side of the glass (3) and on the other side of the glass (3) there is a full face mold (14) with the possible air holes (22), by which the glass (3) can, during and after the bending, be heated to the highest required temperature. For bending on one side of the glass (3) there is a ring mold (15) and / or collar (20) which limit the area of the glass (3) on which the air pressure is exerted by the blower (16) thus bending the glass (3) against the full face mold (14) by the combination effect of the air pressure and the ring mold (15) or the collar (20) simultaneously continuing the glass heating up to the final required temperature, together with functional equipment and control equipment needed to accomplish the necessary process.

STATEMENT UNDER ARTICLE 19

The invention differs from DE-C2-3715151 as according to the method of the invention the temperature is increased in the furnace section to the bending and/or tempering state by the heat conducted from both sides of the glass i.e. from the side of the full face mold and from the side of the ring mold. The glass is not moved to the final bending and heating section when the temperature is the highest but it is moved there at lower temperature. The glass is heated to the final bending and/or tempering temperature in the furnace section (11, 18). Thus the disadvantages that the glass could damage during transfer from preliminary heating zones to final bending and heating zone can be avoided.

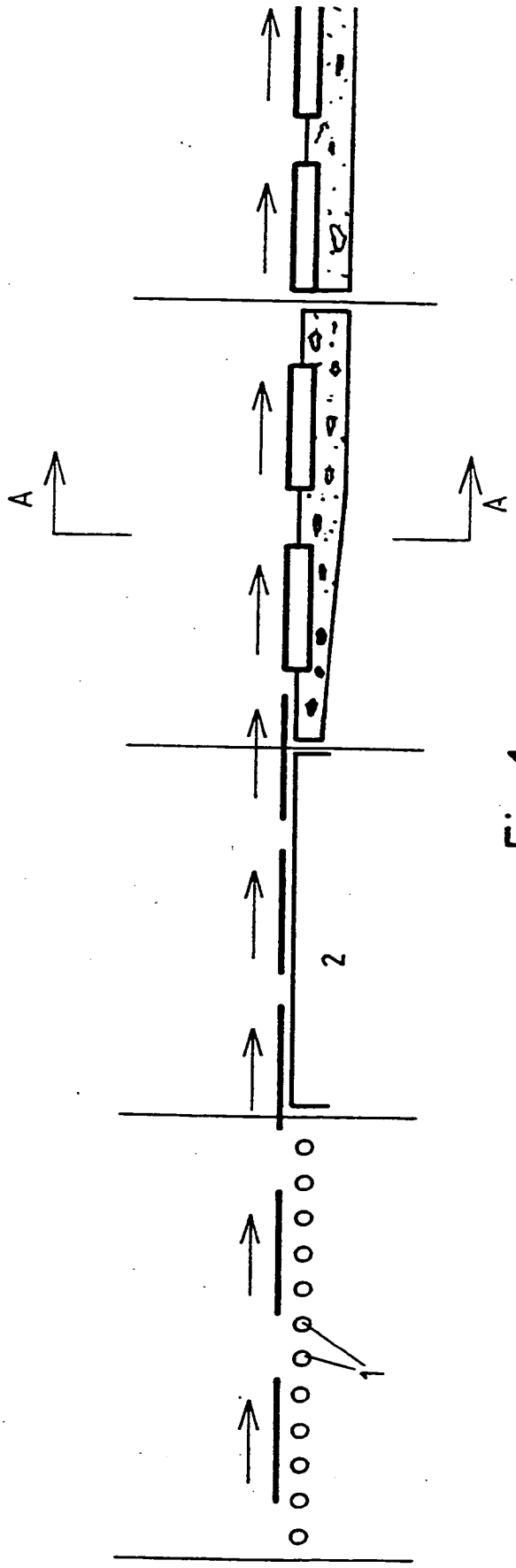

Fig 1

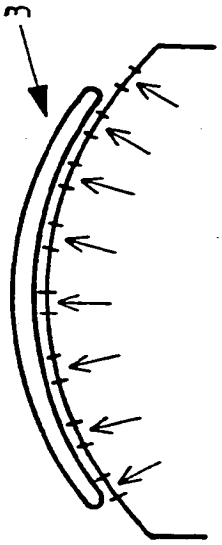

Fig 1A

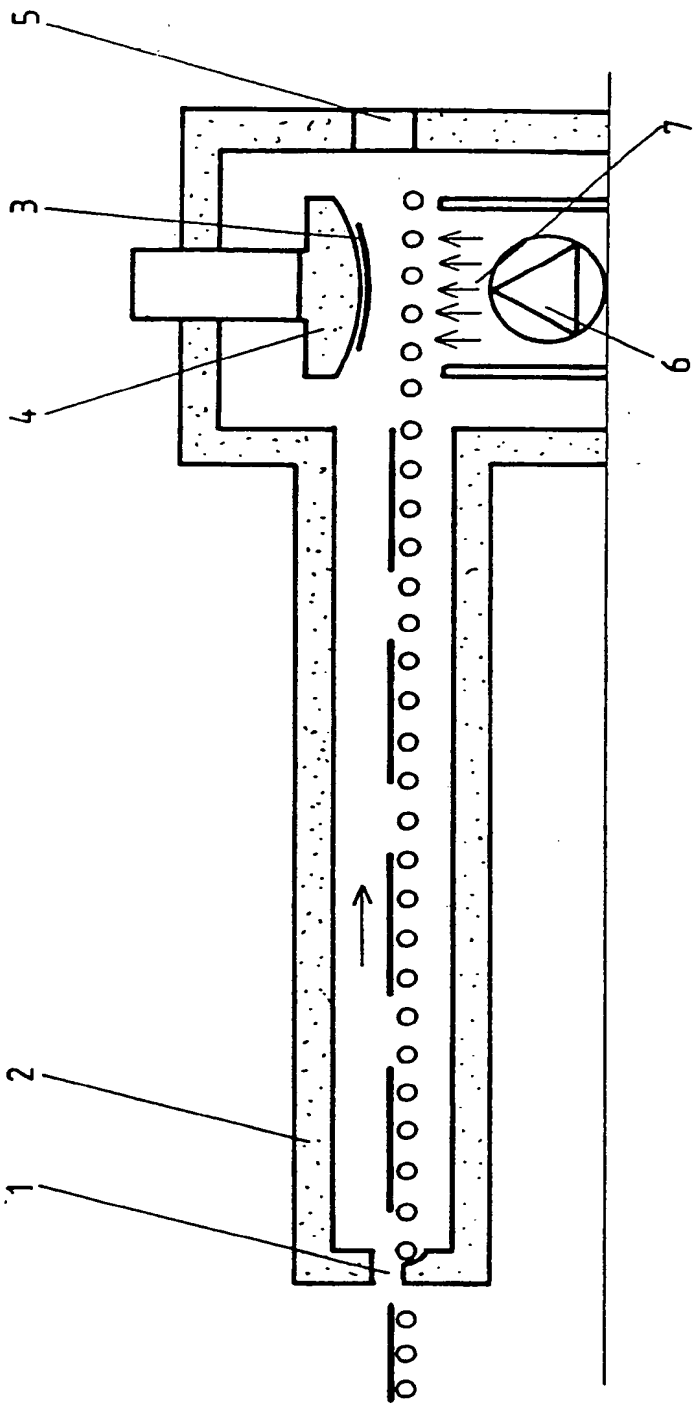

Fig 2

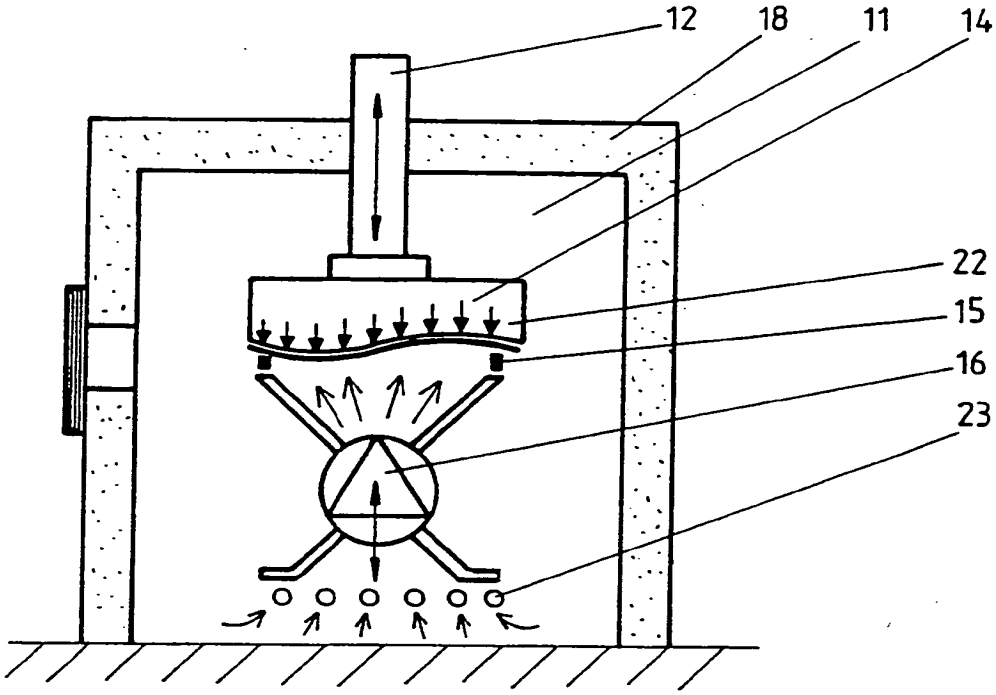

Fig 3

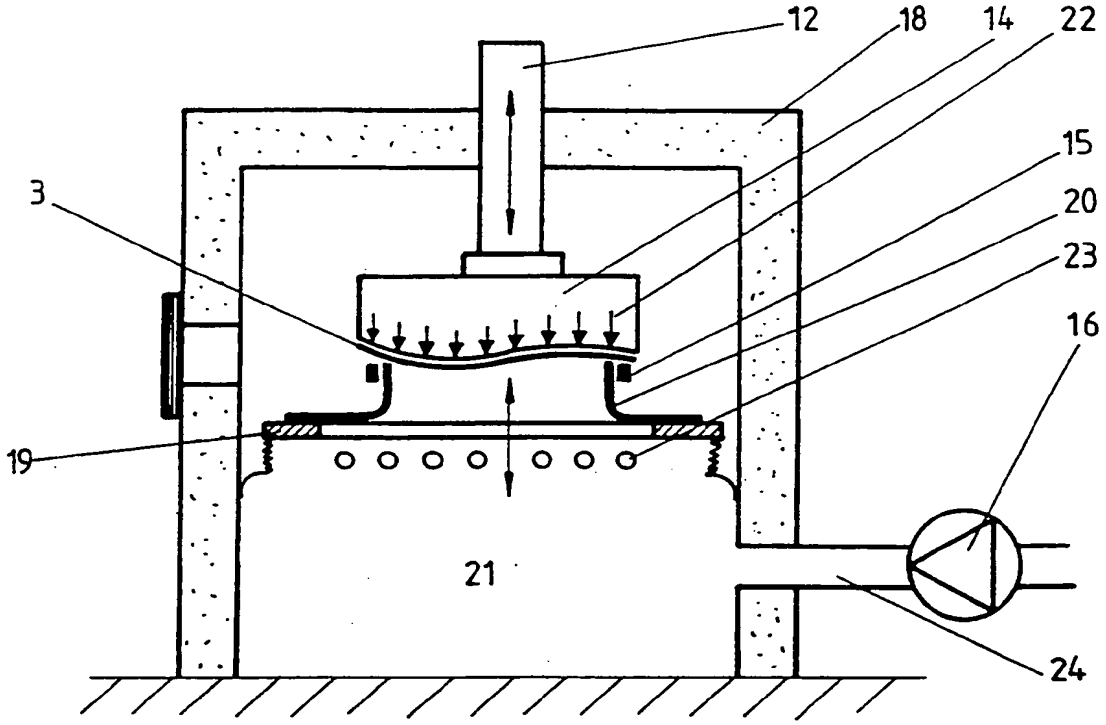

Fig 4

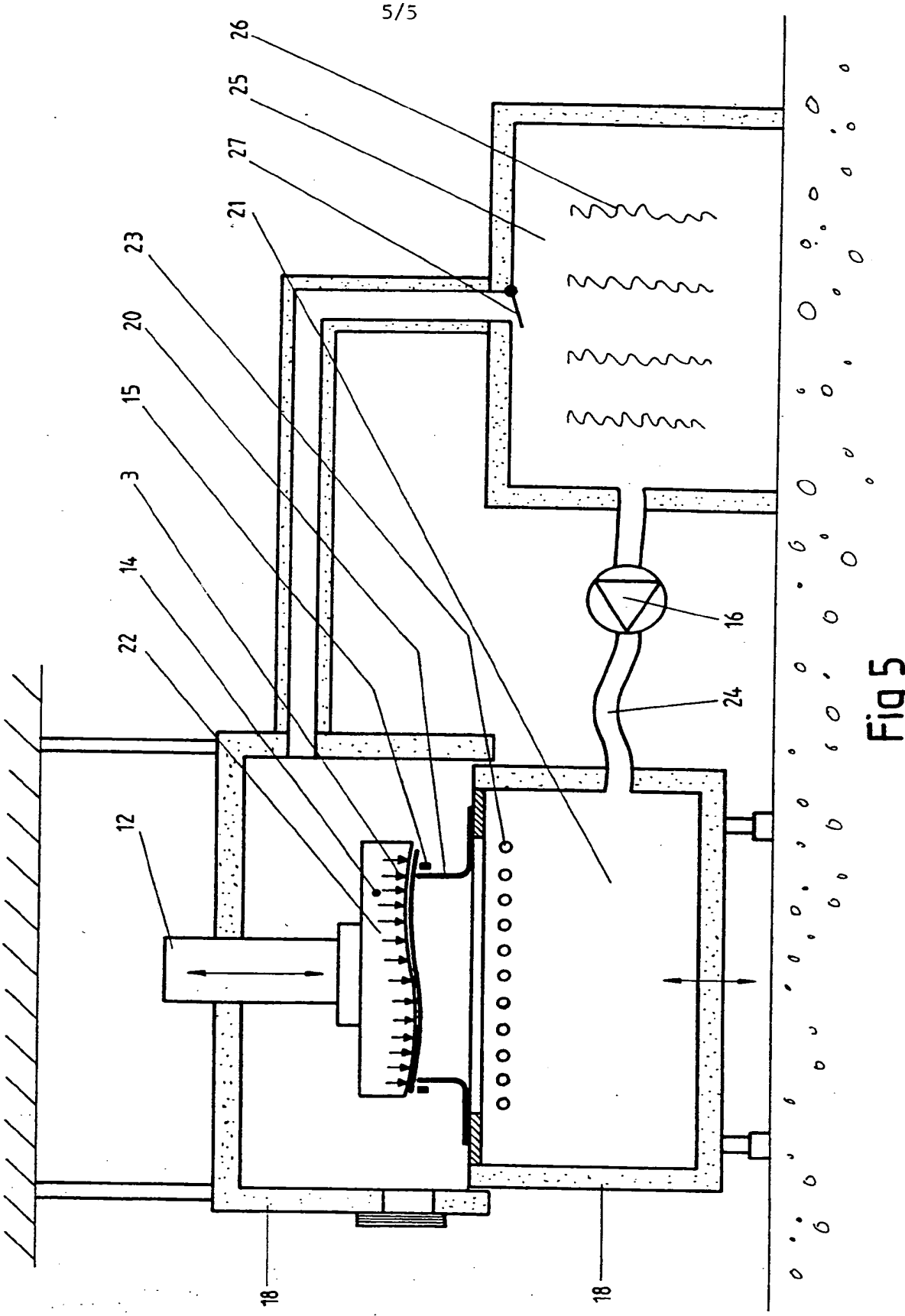

Fig 5

INTERNATIONAL SEARCH REPORT

International Application No PCT/FI 92/00206

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: C 03 B 23/035

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	C 03 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	DE, C2, 3715151 (VEGLA VEREINIGTE GLASWERKE GMBH) 9 November 1989, see column 4, line 36 - line 65; figure 1 --	1-7
A	DE, C2, 3615225 (VEGLA VEREINIGTE GLASWERKE GMBH) 31 August 1989, see the whole document --	1-7
A	DE, C1, 3632556 (VEGLA VEREINIGTE GLASWERKE GMBH) 4 February 1988, see the whole document --	1-7

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* Special categories of cited documents:[10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
25th September 1992	28 -09- 1992
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	May Halline May Halline

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. PCT/FI 92/00206

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the Swedish Patent Office EDP file on 28/08/92
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
DE-C2- 3715151	89-11-09	DE-A-	3865514	91-11-21
		EP-A-B-	0290346	88-11-09
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		US-A-	4859225	89-08-22
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		US-A-	4802903	89-02-07